abling students to comment anonymously on the tutorial. By mapping the student's path, and including their comments at each stage, focussed supplementary tutorials can be provided.

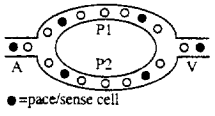
The pilot is undergoing evaluation. Early data is positive for face validity, and compares favourably against conventional methods of teaching such as lectures. On completion the project will undergo a full evaluation process at St George's Hospital Medical School, and elsewhere in the UK.

The CAI runs on a standard PC 486 as well as the Macintosh.

1050-2 Computer Modeling for Real-time Interactive Demonstration of Reentry and Induction of Tachycardia: A Teaching Tool

Hue-Teh Shih, Liew Shin Wu, Edith Shin Wu. *University of Texas Medical School at Houston, Houston, TX; Johnson Engineering Co., Houston, TX*

The induction and termination of reentrant tachycardia are difficult to conceive with electrograms only. An interactive computer model based on conduction and refractory time is constructed for real-time simulation of reentry. Written in Microsoft C++ v. 6.0, 2 pathways (P1, P2) connected at both ends (A, V) are created. There are 2 cells at each end and 7 cells in each pathway (Figure). There is 1 simulated electrogram each for surface ECG, atrium, the 2 pathways, and ventricle. The cell "on" time (I), "off" time (O), and stimulation threshold can be changed. The cells are in a "ready" state when they are not "on" or "off", with different designated colors. The model can be "paced" from the pace/sense cells with various coupling intervals (C), and the cells will be sequentially turned "on" after I of the preceding cell, if they are "ready". After I, the cells become "off" for the duration of O (i.e. refractory time) before returning to "ready". The simulated electrograms in the respective channels show the P (or A) and QRS (or V) waves corresponding to the "on" state of the pace/sense cells. The "surface ECG" also shows T waves during the "off" state of the V end. The sum of I of the 7 cells determines the pathway conduction time. I of the 2 pathways can also be determined by an equation to simulate the properties of the atrioventricular node: $I = AH_\infty + D^*\exp(-C/\tau)$. I and C represent the A_2H_2 and A_1A_2 intervals respectively, AH_∞ is the asymptotic cycle length approached as A_1A_2 increases, and D and τ are constants. AH_∞, D, and τ obtained from curve fitting can be changed to simulate clinical cases. Decremental pacing or extrastimuli can induce or terminate reentrant tachycardia of the computer, as seen from the propagation of cell activation and the simulated electrograms. *Conclusion:* It is feasible to create an interactive computer model for real-time simulation of reentry based on the conduction and refractory time of 2 pathways. This model can be a useful teaching tool for reentry.



701 Predictors of Restenosis

Monday, March 20, 1995, 10:30 a.m.–Noon
Ernest N. Morial Convention Center, Room 24

10:30

701-1 Relationship of Coronary Lesion Length to Late Angiographic and Clinical Outcome After Successful Balloon Angioplasty

David P. Foley, Rein Melkert, David Keane, Andonis G. Violaris, Patrick W. Serruys. *Thoraxcentre, Erasmus University, Rotterdam, Netherlands*

The influence of target lesion length, measured by an automated edge detection system (CAAS), on late angiographic and clinical outcome after successful coronary balloon angioplasty (BA), was investigated among 3124 patients with 3513 non-occlusive native coronary lesions. Quantitative angiography was performed before and after BA and at 6 month follow up. Visually assessed post-BA diameter stenosis <50% was considered successful. Late clinical outcome was considered as occurrence of or freedom from, major adverse cardiac events ("MACE": death, myocardial infarction, coronary artery bypass graft surgery, re-intervention), or target lesion reocclusion at follow up angiography, within 6 months of BA. In univariate analysis, longer lesions were associated with larger reference vessel diameter ($p < 0.0001$) and greater acute luminal gain ($p < 0.01$), but also greater late loss ($p < 0.001$) and greater % stenosis at follow up ($p < 0.0001$). To determine whether lesion length is an independent determinant of late loss or late luminal diameter, multiple linear regression analysis was carried out, including the influence of lesion location, vessel size, pre-procedural minimal luminal diameter and procedural luminal gain. Although lesion length was associated with larger vessel size, which is an independent determinant of less luminal loss ($p < 0.0001$), longer lesions were found to be independently associated with *greater* late loss and a smaller luminal diameter at follow up. Dividing the lesion population in 9 equal groups (noniles), the shortest lesions (mean 2.98 ± 0.66 mm) had a loss of 0.25 ± 0.49 mm and a % stenosis at follow up of 43 ± 20% while the longest (mean 10.86 ± 1.70 mm) had a loss of 0.37 ± 0.55 mm and a % stenosis at follow up of 50 ± 19% ($p < 0.0001$). Despite these angiographic findings of poorer late angiographic results, the frequency of major adverse cardiac events, total occlusion or binary restenosis (diameter stenosis ≥50%) at follow up, did not vary with lesion length.

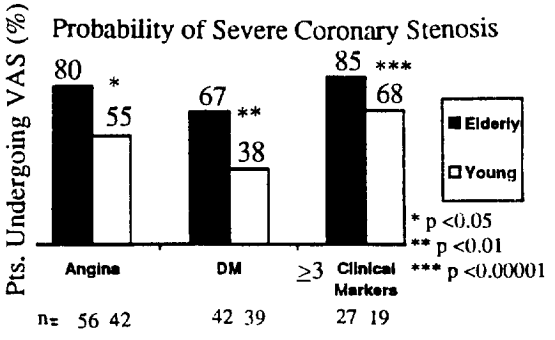
Conclusion: Although longer coronary lesions are independently associated with less favourable late angiographic results after successful balloon angioplasty, this does not appear to translate into poorer late clinical outcome. The long term clinical implications of angiographically quantified preinterventional lesion length remain to be determined.

10:45

701-2 The Final % Cross-sectional Narrowing (Residual Plaque Burden) is the Strongest Intravascular Ultrasound Predictor of Angiographic Restenosis

Gary S. Mintz, Ya Chien Chuang, Jeffrey J. Popma, Augusto D. Pichard, Kenneth M. Kent, Lowell F. Satler, Theresa A. Bucher, Jennifer Griffin, Martin B. Leon. *Washington Hospital Center, Washington, DC*

We analyzed clinical, intravascular ultrasound (IVUS), and angiographic predictors of restenosis (follow-up quantitative angiographic % diameter stenosis >50) in 384 lesions (133 LAD, 42 LCX, 121 RCA, 88 SVG) in 322 pts (259 males, ages 59 ± 11 yrs). Transcatheter devices were 56 PTCA; 126 directional, 70 rotational, and 3 extraction atherectomy; 56 stents; and 73 excimer laser angioplasty. Univariate IVUS parameters tested included reference site and target lesion pre- and post-intervention external elastic membrane (EEM), lumen, and plaque areas; % cross-sectional narrowing (%CSN = plaque/EEM area); and lesion morphology (eccentricity, plaque composition, calcium, and dissections). Using multivariate analyses, the most consistent predictor of follow-up angiographic findings was the IVUS final % CSN. Using logistic regression analysis, the final %CSN predicted restenosis (odds ration 2.09; 95% confidence interval = 1.50–2.92, $p < 0.001$, Figure); using linear regression analysis, %CSN predicted both the follow-up angiographic % diameter stenosis ($r = 0.371$, $P < 0.001$) and minimum lumen diameter ($r = 0.396$, $p < 0.001$). In addition, various *reference* segment measurements (eg., angiographic lumen diameter or IVUS EEM or lumen area or %CSN) were included in some of the multivariable models; but no one measure of reference vessel size or disease consistently predicted follow-up results. Importantly, the following did not predict restenosis: (1) lesion morphology and (2) mechanisms of lumen enlargement (increase in EEM or decrease in plaque). *We Conclude:* The final IVUS %CSN was a more powerful predictor of restenosis than clinical or angiographic variables. *Either* an increase in EEM (vessel expansion) *or* a decrease in plaque (tissue removal) will reduce the final % CSN. Thus, it is the magnitude, not the mechanism, of successful transcatheter therapy that is related to freedom from restenosis.



11:00

701-3 Prediction of the Risk of Angiographic Restenosis by Intracoronary Ultrasound Imaging After Coronary Balloon Angioplasty

Ron J.G. Peters, PICTURE Study group (Post Intra Coronary Treatment Ultrasound Result Evaluation). *InterUniversity Cardiology Institute, Utrecht, The Netherlands*

The aim of the PICTURE study is to relate arterial wall morphology on intracoronary ultrasound images (ICUS) after balloon angioplasty (BA) to the risk of quantitative coronary angiographic (QCA) restenosis at 6 months. Of the 200 patients included, data are now complete in 133. With 112 (84%) repeat angiograms and 8 patients with 2 lesions, 119 lesions were available for interim analysis. A >50% diameter stenosis on QCA at 6 months was present in 30.3%. On QCA after BA, mean minimal lumen diameter was 1.71 in the